

FINAL EXAM REVIEW

Bring: pencils, pens, eraser, calculator

Study: by DOING, not just reading. Make study notes and **practice** answering questions. Use notes, assignments, quizzes and tests for guidance.

Exam Structure:	Part A: Multiple Choice	30 marks
	Part B: True/False	10 marks
	Part C: Short Answer	69 marks
		TOTAL = 109 marks

Unit 1 - Structure and Properties

Aufbau principle, electron configuration, Hund's rule, orbital, Pauli exclusion principle, quantum numbers (n , l , m_l , m_s), bond dipole, covalent bond, dipole-dipole force, hydrogen bonding, intermolecular force, ionic bond, London force, nonpolar bond, nonpolar molecule, polar bond, polar covalent bond, polar molecule, VSEPR, pi (π) bond, sigma (σ) bond.

- Determine the maximum number of electrons with a principal quantum number
(a) 1 (b) 2 (c) 3 (d) 4
- How many quantum numbers does it take to fully describe an electron in an atom? Provide and example, listing labels and values of each quantum number.
- Write a complete ground-state electron configuration for each of the following atoms or ions:
(a) Mg (b) S^{2-} (c) K^+ (d) Rb (e) Au
- Use VSEPR theory to predict the geometry and hybridization of a molecule of each of the following substances.
(a) BeI_2 (b) PF_3 (c) H_2S (d) BBr_3
(e) $SiBr_4$ (f) HCl (g) PO_4^{3-} (h) IO_3^-
- Based upon intermolecular forces, predict which substances in the following pairs has the higher boiling point. Provide your reasoning.
(a) beryllium fluoride or oxygen difluoride
(b) chloromethane or ethane
(c) water or hydrogen sulfide

Unit 2 - Organic Chemistry

Addition reaction, alcohol, aldehyde, alkane, alkene, alkyl group, alkyl halide, alkyne, amide, amine, phenol, aromatic hydrocarbon, carbonyl group, carboxylic acid, carboxyl group, combustion reaction, condensation reaction, cyclic hydrocarbon, elimination reaction, ester, esterification, ether, functional group, hydration reaction, hydrocarbon, hydrolysis, hydroxyl group, isomer, ketone, organic halide, oxidation reaction, polyalcohol, primary alcohol, secondary alcohol, substitution reaction, tertiary alcohol, addition polymerization, condensation polymerization.

6. Draw the following organic molecules
- | | |
|---------------------------------|----------------------------|
| (a) 3,3,5-trimethyloctane | (f) hexan-2-one |
| (b) 4-ethyl-3,4-dimethylheptane | (g) methyl butanoate |
| (c) cyclopentene | (h) decanoic acid |
| (d) octan-3-ol | (i) N-ethyl pentan-2-amine |
| (e) butanal | (j) heptanamide |
7. Use structural diagrams to show the following reactions. Be sure to include any catalysts, and name each organic compound in the reaction
- the oxidation of propan-2-ol
 - the oxidation of propan-1-ol
 - the condensation reaction between ethanol and butan-1-ol
 - the esterification to create hexyl pentanoate

Unit 3 - Energy Changes and Rates of Reactions

Calorimetry, chemical change, chemical system, endothermic, enthalpy, exothermic, heat, Hess's Law, molar enthalpy, molar enthalpy of reaction, open system, physical change, potential energy diagram, specific heat capacity, standard enthalpy of formation, surroundings, temperature, thermal energy, activated complex, activation energy, average rate of reaction, catalyst, collision theory, instantaneous rate of reaction, rate-determining step, rate of reaction, reaction intermediates.

8. The molar enthalpy of solution of ammonium chloride is +14.8 kJ/mol. What would be the final temperature of a solution in which 40.0 g of ammonium chloride is added to 200.0 mL of water, initially at 25°C?
9. The molar enthalpy of combustion of decane (C₁₀H₂₂) is -6.78 MJ/mol. What mass of decane would have to be burned in order to raise the temperature of 500.0 mL of water from 20.0°C to 55.0°C?
10. In a laboratory investigation into the neutralization reaction
- $$\text{HNO}_3(\text{aq}) + \text{KOH}(\text{s}) \rightarrow \text{KNO}_3(\text{aq}) + \text{H}_2\text{O}(\text{l})$$
- a researcher adds 5.2 g of solid potassium hydroxide to 200.0 mL of 1.0 M nitric acid solution in a polystyrene calorimeter. The temperature changes from 21.0°C to 28.1°C. Calculate the molar enthalpy of neutralization of potassium hydroxide.
11. Use standard enthalpies of formation to calculate:

- (a) the molar enthalpy of combustion for pentane to produce carbon dioxide gas and liquid water
- (b) the enthalpy change that accompanies the reaction between solid iron(III) oxide and carbon monoxide gas to produce solid iron metal and carbon dioxide gas

12. The experimental observations in the table are obtained for the reaction $2A + B + 2C \rightarrow 3X$.

Table 1. Observations on the Rate of Production of X

Trial	Initial [A] (mol/L)	Initial [B] (mol/L)	Initial [C] (mol/L)	Rate of production of X (mol/(L·s))
1	0.10	0.10	0.10	3.0×10^{-4}
2	0.20	0.10	0.10	1.2×10^{-3}
3	0.10	0.30	0.10	3.0×10^{-4}
4	0.20	0.10	0.20	2.4×10^{-3}

- (a) What is the order of reaction with respect to each of the reactants?
- (b) Write an expression for the rate equation.
- (c) Calculate a value for the rate constant.
- (d) Calculate the rate of production of X when $[A] = [B] = [C] = 0.40 \text{ mol/L}$

13. Draw a kinetic energy distribution diagram with labelled curves for lower (T_1) and higher (T_2) temperatures. On the diagram draw a line to represent the threshold energy for the reaction. Summarize the effects of temperature by shading and labelling areas to represent the fraction of molecules able to react.

Unit 4 - Chemical Systems and Equilibrium

Chemical reaction equilibrium, closed system, common ion effect, dynamic equilibrium, equilibrium constant (K), equilibrium law expression, equilibrium shift, forward reaction, LeChâtelier's principle, percent reaction, quantitative reaction, reaction quotient (Q), reverse reaction, solubility, solubility equilibrium, solubility product (K_{sp}), trial ion product, acid-base indicator, acid ionization constant (K_a), base ionization constant (K_b), Bronsted-Lowry acid and base, conjugate acid-base pair, endpoint, equivalence point, ion product constant for water (K_w), monoprotic acid, pH, pOH, polyprotic acid, strong acid, strong base, titrant, titration, weak acid, weak base.

14. Write the expression of the equilibrium constant for the hydrogen-iodine-hydrogen iodide system at 485 C. Using the values in the table, calculate the value of the equilibrium constant.

Table 2. Experiments with the $\text{H}_{2(g)} + \text{I}_{2(g)} \rightleftharpoons 2 \text{HI}_{(g)}$ Equilibrium

Experiment	Initial concentration (mol/L)			Equilibrium concentration (mol/L)		
	$[\text{H}_{2(g)}]$	$[\text{I}_{2(g)}]$	$[\text{HI}_{(g)}]$	$[\text{H}_{2(g)}]$	$[\text{I}_{2(g)}]$	$[\text{HI}_{(g)}]$
1	2.000	2.000	0	0.442	0.442	3.116
2	0	0	2.000	0.221	0.221	1.560
3	0	0.010	0.350	0.035	0.045	0.280

15. For each example, predict whether, and in which direction, the equilibrium is shifted by the change imposed. Explain any shift in terms of changes in forward and reverse reaction rates.

- | | |
|---|--------------------------------|
| (a) $\text{Cu}^{2+}_{(aq)} + 4\text{NH}_3_{(g)} \rightleftharpoons \text{Cu}(\text{NH}_3)_4^{2+}_{(aq)}$ | $\text{CuSO}_4_{(s)}$ is added |
| (b) $\text{CaCO}_3_{(s)} + \text{energy} \rightleftharpoons \text{CaO}_{(s)} + \text{CO}_2_{(g)}$ | temperature is decreased |
| (c) $\text{Na}_2\text{CO}_3_{(s)} + \text{energy} \rightleftharpoons \text{Na}_2\text{O}_{(s)} + \text{CO}_2_{(g)}$ | sodium carbonate is added |
| (d) $\text{H}_2\text{CO}_3_{(aq)} + \text{energy} \rightleftharpoons \text{CO}_2_{(g)} + \text{H}_2\text{O}_{(l)}$ | volume is decreased |
| (e) $\text{KCl}_{(s)} \rightleftharpoons \text{K}^{+}_{(aq)} + \text{Cl}^{-}_{(aq)}$ | $\text{AgNO}_3_{(s)}$ is added |
| (f) $\text{CO}_2_{(g)} + \text{NO}_{(g)} \rightleftharpoons \text{CO}_{(g)} + \text{NO}_2_{(g)}$ | volume is increased |

16. Lactic acid, $\text{HC}_3\text{H}_5\text{O}_3_{(aq)}$, is a weak acid that gives yogurt its sour taste. Calculate the pH of a 0.0010 mol/L solution of lactic acid. The K_a for lactic acid is 1.4×10^{-4} .

17. Methanoic acid, $\text{HCOOH}_{(aq)}$, also known as formic acid, is partly responsible for the characteristic itchy rash produced by the leaves of the stinging nettle plant. Calculate the pH of the resulting solution if 150.0 mL of 0.150 mol/L methanoic acid is reacted with 100.0 mL of 0.125 mol/L sodium hydroxide. The K_a of methanoic acid is 1.8×10^{-4} .

18. A buffer solution was made by dissolving 10.0 g of sodium acetate in 200.0 mL of 1.00 M acetic acid. Assuming the change in volume when the sodium acetate is not significant, estimate the pH of the acetic acid/sodium acetate buffer solution. The K_a for acetic acid is 1.8×10^{-5} .

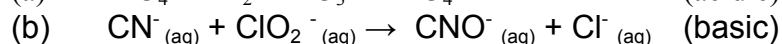
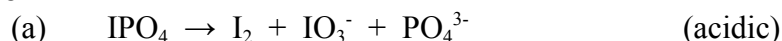
Unit 5 - Electrochemistry

Anode, cathode, electric current, electric potential difference (voltage), electrode, electrolyte, galvanic cell, half-cell, oxidation, oxidation number, oxidizing agent, redox spontaneity rule, reducing agent, reduction, standard cell, standard cell potential

19. Given the potential of the following standard cell with a cadmium anode, predict the reduction potential of the cerium(III) ion half-cell.



20. Write equations for the reduction and oxidation half-reactions, and balanced net redox equation.



21. For each of the following cells,

- use the given cell notation to identify the strongest oxidizing and reducing agents.
- write chemical equations to represent the cathode, anode, and overall (net) cell reactions (include the half-cell and cell reduction potentials).
- draw a diagram of each cell, labelling the electrodes, charges at the electrodes, electrolytes, direction of electron flow, and direction of ion movement.

